are perfectly white, for the red coloured, or veined, specimens contain oxide of iron. In examining these sulphates of lime, the chemist points out how the characters of substances may be disguised by the power of affinity; for sulphuric acid and lime, in a pure or insolated state, are excessively caustic and poisonous, and cannot be exposed to the air without undergoing change; but upon being united they form a compound perfectly neutral, having no poisonous property, and which will endure for ages unchanged, as the sculptured work of many ancient funeral monuments so amply testifies.

Most of the materials employed as paints or colours are salts of metallic oxides. The yellow colour given to old brickwork previous to the operation of pointing, is due to the oxide contained in sulphate of iron or green vitriol, being extracted or precipitated by the greater affinity of lime for the sulphuric acid. White lead is a carbonate of the oxide of lead; blue and green verditter are carbonates of oxide of copper; chrome yellow a compound of chromic acid and oxide of lead, whilst vermilion is a direct compound of sulphur and mercury, or a sulphuret of mercury, and common bronze-powder, a sulphuret of tin.

These examples may suffice to prove how largely the architect, the builder, and the decorative artist draw upon the elementary metals and metallic compounds for materials suited to the pursuit of their respective professions, and that chemistry as applied to construction presents many important and useful facts to their notice. But we can proceed further; let us turn our attention to some of the non-metallic elements and their compounds or mixtures. The basis of all black paints is *carbon*, in various states of mechanical division, known as lamp-black, ivory-black, and vegetable black. The very pencil point with which the design of the palace or the cottage may be traced, although familiarly called "black lead," does not contain a particle of lead; it is a variety of carbon, in a pure and soft state; and the diamond, employed by the artificer to cut the tables of glass, is the same element carbon, absolutely pure, crystalline, and the hardest substance known to the experimentalist.

This same Protean element carbon, as elicited by the decomposition of organic remains, confers the blackness upon the much admired marble called *Luculite*; and if the chemist cause affinity to ensue between carbon and iron, the result is cast-iron and steel; without the latter compound fashioned into tools, the architect could not have his designs properly and effectually executed.

Another extraordinary element is *hydrogen*. Although never presented pure by nature, it exists in combination with oxygen to constitute water, a liquid of the most universal employment for tempering clay, mixing cement, stains, colours, and for aiding the sawing, grinding, and polishing of marble, stone, glass, metals, and so forth.

But water, thus useful and indispensable, is a natural agent against whose effects it is the constant aim of the architect and builder to be prepared, for it contributes in no small degree both mechanically and chemically to the disintegration and decay of many materials employed in construction.

These may appear perfectly compact, yet close examination proves them to abound in minute pores, which, in virtue of an attraction purely mechanical, called capillary attraction (like that of a sponge), eagerly absorb, and tenaciously retain, water derived from the clouds or from the humid soil of foundations, and thus remain damp; some idea of the extent to which this absorption and retention takes place may be formed from the fact, that a single good and apparently sound stock brick, such as is employed in the generality of metropolitan buildings will absorb and retain upon the average eleven ounces of water.

Accordingly, if mortar or cement be laid on dry bricks, the water is rapidly absorbed, and little or no cementation takes place; hence the utility of soaking the bricks in water, or lime water, to fill the pores, so that the water of the mortar may be not rapidly, but gradually absorbed, as the brickwork dries, supposing always the situation is suitable for the drying to ensue.

If porous brick or stone-work saturated with water be exposed to frost, the water passes from the liquid to the solid state, or in more familiar terms freezes, and in so doing it expands with vast force, a force that the particles of the materials are unable to withstand; accordingly, they are riven asunder, chiefly at the surface, and in the course of time by the alternations of thaw, frost, and heat, a considerable amount of disintegration and decay is the consequence; many public buildings present striking examples of this fact.

Water forms an essential, and, in many cases, a truly definite, constituent of building materials. Thus *slaked* lime, although it may feel perfectly dry, in every 100 parts, contains 25 parts of water, and such lime the chemist terms *hydrate of lime*. The above quantity of water is theoretically required to slake 75 parts of quicklime, although in practice, a larger quantity is generally added; alabaster and gypsum owe their beauty, translucency, and compactness, to the presence of water, chemically combined in the proportion of about 20 per cent., and are *hydrated* or *anhydrous* sulphate of lime, if the water be expelled by the action of heat, they become opaque white, and *anhydrous*.

Thus plaster of Paris is *anhydrous*, and when artificially mixed with water, the well-known property of setting and hardening is due to affinity between the sulphate and the water, by which the latter is solidified.

Water, although so abundant throughout nature, is never chemically pure, or solely consistent of its two elements, hydrogen and oxygen; it contains various saline matters derived from the strata of the earth, and these impurities, however minute in quantity, perfectly interfere with its use in refined experiments; and where they exist in abundance, as in some kinds of river water, or more especially in sea water, they interfere with its employment by the architect and builder. The purity of water employed in mixing clay, mortar, cement, and colours, although a matter of great importance, is but too often neglected by practical men, and the consequence is, that blotches and efflorescences disfigure the work, originally destined to be fair and beautiful.

To those who have not made the science of chemistry a branch of study, the foregoing statements as to the earths and earthy materials (popularly so called), being metallic oxides, may appear extraordinary. If this be the case, how much more extraordinary will appear the ensuing statement,—that all kinds of timber consist of the elements *oxygen*, *hydrogen*, and *carbon*! but such is the chemical fact; and not only consist of these non-metallic and diametrically different elements, but in definite weights, so exactly apportioned, that their individual characters are as perfectly neutralized as in the case of sulphuric acid and lime, when united to form alabaster.

In perfectly good, dry timber, free from any great excess of turpentine, resinous matter, or knots—say, for example, well-dried American pine—the elements, oxygen and hydrogen, are found in the exact proportions requisite to the constitution of *water*, and these combined with an equal weight of the element *carbon*. The accumulation, the elaboration of these three elements by the vital, or organic powers or functions of the vegetable kingdom is most wonderful, and upon it the chemist reflects and experiments with the full intensity of delight and admiration;—it throws all his limited artificial operations into the shade of insignificance.

Look, for example, at the dry timber of an oak tree, weighing say thirty tons; look at its hardness, its compactness, its strength, its durability, and then reflect for a moment upon the statement that the chemist can make regarding its composition! it will "move our especial wonder."

Who would imagine that the timber of the tree contained, in a solid state, the identical elements of the flowing river upon whose banks it grew and flourished, combined with the elementary matter of the sparkling diamond?

But such is the chemical truth; for in the thirty tons of dry oak timber there are consolidated fifteen tons of *water* and fifteen tons of *carbon*.

Then again, the pure matter of wood, thus constituted, or woody fibre or *lignin*, as it is called, wonderfully elaborated by the hand of nature, chemically the same as that of solid oak, mechanically different in point of aggregation, presents every variety of hemp, flax, and cotton. These valuable organic forms, by artificial processes, are manufactured into canvass, linen, calico, and paper, and all used in construction, either in a plain state as they are sent forth from the loom or paper-machine, or most elaborately or richly adorned with chemical elements or compounds under the hands of the decorative artist, to constitute the magnificent paintings in oil or water colours, or the stained hangings which embellish the walls of a finished edifice.

The very same elements, oxygen, hydrogen, and carbon, in other proportions, and especially with more hydrogen than is essential to the formation of water, constitute the black and solid coal, the white and solid wax, the yellow and liquid oil, which are employed for warming and illuminating our dwellings; and coal, when artificially deprived of oxygen, leaving only hydrogen and carbon in combination, forms the transparent, invisible, inflammable gas, which is rapidly superseding all other materials for artificial illumination. Resins, gums, bitumens, the alcohol, the oils in which they are dissolved to constitute varnish, lacquer, and polish, consist of the three elements, oxygen, hydrogen, and carbon.

But the materials for an edifice would be incomplete without the stores of chemical compounds that abound in the animal kingdom; and in seeking out the ultimate elements of this wonderful and elaborate realm of nature, the chemist arrives at the extraordinary—the inexplicable conclusion, that animal products contain the same elements as those of vegetables, with the addition, in the generality of cases, of the element *nitrogen*.

Glue, size, serum, and albumen of blood, parchment, all used for cements or distemper painting, contain the above four elements, and so likewise the hair, feathers, and down of the luxurious chair or sofa, its silken covering, the silken hangings, the soft deeply piled carpet.

And lastly, when the mineral, vegetable, and animal kingdoms have been each in turn explored and ransacked by the architect and builder for the materials of an edifice, the agency of an imponderable element, by which they are all more or less affected, has to be well and correctly examined,—viz., the universal and all-important agency of *heat*,—or vain will be the attempt to render the edifice a comfortable habitation.

The most general effect of heat upon the three physical states or forms of matter, is to cause their expansion or enlargement of bulk; and amongst solid substances the metals and their alloys are most susceptible of this change. Thus, if a bar of metal be accurately measured in length and diameter at the temperature of 32°, and then exposed to the heat of the sun at 70°, it will be found to have sensibly increased in bulk.

The chemist discovers that all metals will expand by heat, but some do so much more than others; thus lead is the most expansile of the common metals, and platinum the least. This expansion takes place with enormous force, which no mechanical power can restrain.

Native and artificial compounds, such as granite, limestone, marble, wood, brick, plaster, stucco, and so on, also expand by heat, but in a degree vastly inferior to the metals and their alloys; but in all cases the expansion is temporary, and the various substances return to their original dimensions when the heat is withdrawn, or, in other words, when they are cooled to the degree that they had at the outset of their measurement.

In reference to the materials employed in construction, knowledge regarding their expansion by heat and contraction by cold is of the utmost importance to the architect, for their dimensions are constantly undergoing changes by the ordinary fluctuations of atmospheric temperature. Iron, or other tenacious metal, is frequently introduced into stone or brickwork, for the purpose of conferring stability upon a structure; but, if injudiciously employed, becomes the most active agent in promoting its instability. Thus, during a warm day, the metal becomes heated, it expands in all directions,—so does the stone or brickwork, but not to an equal extent; and, therefore, it is thrust out of position, and remains where thrust, so long as the heat of the day continues; but as the cool of night approaches, the metal cools and contracts rapidly to its original dimensions, whilst the contrac-